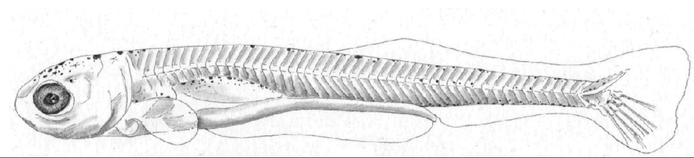
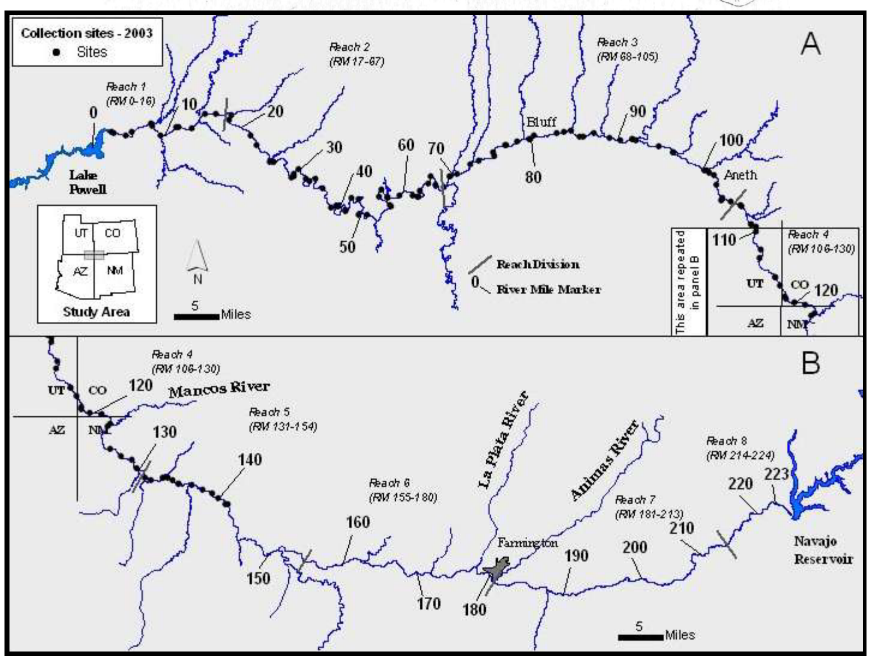
Colorado pikeminnow larval fish survey in the San Juan River during 2003

DRAFT REPORT





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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

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submitted to:

San Juan River Basin Biology Committee
under the authority of the
San Juan River Basin Recovery Implementation Program

31 March 2004

Table of Contents

List of Tables

List of Figures

Executive Summary

1. There were 180 fish collections at 160 unique sites made between river miles 141.5 and 2.9 during the 2003 Colorado pikeminnow larval fish survey.

2. The 180 samples resulted in the collection of fish representing six families and 12 species, with all but two samples producing fish.

3. There were 95 more samples taken in 2003 than in 2002, however 2003 produced over 20,000 fewer fish than 2002 (n=70,353 and 90,518 respectively).

4. Non-native cyprinids accounted for 94.1% (n=66,185) of the 2003 catch by number. Red shiner was the numerically dominant (n=53,253) and most frequently encountered species, occurring in 177 of the 179 samples that produced fish.

5. Native species accounted for 3.0% (n=2,097) of the 2003 catch by number. Speckled dace was the numerically dominant (n=1,383) and most frequently encountered native species, occurring in 108 of the 179 samples that produced fish.

6. Catostomids accounted for 1.0% (n=712) of the 2003 catch by number. Blue sucker was the numerically dominant catostomid taxon, accounting for 88.2% of all catostomids collected. Flannelmouth sucker accounted for 11.8% of all catostomids collected, with no razorback sucker collected in 2003.

7. Reach 3 produced more fish than any of the other reaches sampled and also yielded the highest numbers of flannelmouth and bluehead suckers (n=59 and 384 respectively).

8. Reach 2 produced fewer fish than any of the other reaches sampled and was the only reach to produce a sample in which no fish were collected.

9. No larval Colorado pikeminnow were collected in 2003.

10. A single sub-adult (201 mm SL) Colorado pikeminnow was collected on 15 July 2003 in a shoreline pool at river mile 54.4.

Introduction

Background Information

Colorado pikeminnow, *Ptychocheilus lucius*, is a federally endangered species (U.S. Department of the Interior, 1974) endemic to the Colorado River Basin where it was once abundant and widespread (Tyus, 1991). This species now occupies only about 20% of its historic range (Tyus, 1990). The Green River sub-basin apparently supports the majority of remaining Upper Basin individuals (Holden and Wick, 1982; Bestgen et al., 1998). Conversely, no Colorado pikeminnow have been reported in the Lower Basin since the 1960s (Minckley and Deacon, 1968; Minckley, 1973; Moyle, 1976).

A small but self-sustaining population of this species occurs in the lower-most 225 river km (between Cudei Diversion Dam and the inlet of Lake Powell Reservoir) of the San Juan River. The decline of this and other native fishes in the San Juan River has been attributed to flow modifications and the resultant changes to the thermal regime, instream barriers, and non-native predation-competition for habitat and resources. Understanding the conditions necessary for spawning in Colorado pikeminnow and other native fishes was deemed necessary to stabilize and increase the population size of this species.

Much has been reported regarding the life-history and reproductive behavior of Colorado pikeminnow (Vanicek and Kramer, 1969). Studies in the Upper Colorado River Basin (Yampa and Green rivers) have demonstrated that this species spawns as spring runoff is receding and at water temperatures between 18^{o}C and 20^{o}C (Haynes et al., 1984; Nesler et al., 1988). Larval Colorado pikeminnow employ drift as a dispersal mechanism and are presumed to begin this passive movement approximately five days after hatching. The five-day time-frame corresponds with the swim-up period of this fish as reported by Hamman (1981, 1986).

This life-history phase (drifting larvae), the focus of several investigations in the Upper Colorado River Basin, has been investigated to provide information on spawning bar location, reproductive success, and the effects of various flow-regimes on reproduction. The collection of a juvenile (177 mm TL) Colorado pikeminnow in 1978 (Minckley and Carothers, 1979) and rediscovery of a reproducing population of Colorado pikeminnow in the San Juan River in 1987 (Meyer and Moretti, 1988; Platania and Bestgen, 1988; Platania et al., 1991) demonstrated a need for studies to ascertain information such as that obtained for this species in the Upper Colorado River Basin. Such studies would also provide comparable information on other members of the ichthyofaunal community.

In 1991, passive drift-netting for larval and young-of-year (YOY) fish was initiated in the San Juan River. The primary objectives of the passive drift-netting study were to 1) determine the temporal distribution of San Juan River ichthyoplankton in relation to the hydrograph, 2) provide comparative analysis of the reproductive success of San Juan River fishes, 3) attempt to characterize downstream movement of ichthyoplankton, and 4) attempt to validate the presumed spawning period of Colorado pikeminnow.

Passive drift-netting on the San Juan River at Mexican Hat was conducted by the Utah Division of Wildlife Resources (UDWR) during 1991-1994, samples at Four Corners were taken by New Mexico Department of Game and Fish (NMGF) during 1991-1994, and both sites were sampled by personnel at the Museum of Southwestern Biology, Division of Fishes at the University of New Mexico (UNM) during 1995-2001. Results from the 1991-1997 portion of the drift-net study were presented in a report by Platania et al. (2000) and will not be discussed in this report.

In 2000 a different passive sampling device, the Moore Egg Collector (Altenbach et al., 2000), was used, with similar results to drift-nets (2,138 specimens were collected). Between 1991-2000, only 20,901 specimens (and few Colorado pikeminnow) were collected in the passive sampling effort (Table 1). Meanwhile, the larval seining method had proven successful in larval razorback sucker fish surveys by UNM personnel between 1998-2000. The sampling protocol in 2001 included a combination of passive drift-netting and active sampling with larval seines, and results from that study year will not be discussed in this report.

Table 1. Summary of larval and YOY Colorado pikeminnow collected in the San Juan River (1993-2003) and back calculated dates of spawning.

Field Number	MSB Catolog Number	Number of specimens	Total Length	Date Collected	Date Spawned	River Mile	Sample Method
MH72693-2	18098	1	9.2 mm	26 Jul 93	08 Jul 93	53.0	Drift netting
MH72793-2	18099	1	9.2 mm	27 Jul 93	09 Jul 93	53.0	Drift netting
JPS95-205	26187	1	9.2 mm	02 Aug 95	15 Jul 95	53.0	Drift netting
JPS95-207	26191	1	9.0 mm	03 Aug 95	17 Jul 95	53.0	Drift netting
WHB96-03	29717	1	8.6 mm	02 Aug 96	18 Jul 96	128.0	Drift netting
FC01-054	50194	1	8.9 mm	01 Aug 01	18 Jul 01	128.0	Drift netting
TOTAL		6					

After a decade of passive sampling, these methods (with the exception of occasional use of light-traps) were discontinued in 2002 in favor of active sampling with larval seines. In 2002, over four times as many specimens were collected (n=90,518) than in the previous ten years combined. The new sampling protocol was continued during 2003 and resulted in the collection of over 70,000 specimens.

Study Area

The San Juan River is a major tributary of the Colorado River and drains 99,200 km^2 in Colorado, New Mexico, Utah, and Arizona (Figure 1). From its origins in the San Juan Mountains of southwestern Colorado at elevations exceeding 4,250 m, the river flows westward for about 570 km before confluencing with the Colorado River. The major perennial tributaries to the San Juan River are (from upstream to downstream) Navajo, Piedra, Los Pinos, Animas, La Plata, and Mancos rivers, and McElmo Creek. In addition there are numerous ephemeral arroyos and washes that contribute relatively little flow annually but input large sediment loads.

Navajo Reservoir, completed in 1963, impounds and isolates the upper 124 km of the San Juan River and regulates downstream discharge. The completion of Glen Canyon Dam in 1966 and subsequent filling of Lake Powell ultimately inundated the lower 87 km of the San Juan River by the early 1980s. The San Juan River is now a 359 km lotic system bounded by two reservoirs (Navajo Reservoir near its head and Lake Powell at its mouth).

The San Juan River is canyon-bound and restricted to a single channel between its confluence with Chinle Creek (ca. 20 km downstream of Bluff, Utah) and Lake Powell. The river is predominatly multi-channeled upstream of Chinle Creek with the highest density of secondary channels occurring between Bluff and the Hogback Diversion (ca. 13 km upstream of Shiprock, New Mexico). There is a general downstream decline in channel stability in the section of river between Bluff and Shiprock. Below the confluence with the Animas River near Farmington, New Mexico, the channel is less stable and more subject to floods from it largest and unregulated tributary, the Animas River. Conversely, the regulated reach of river between Farmington, New Mexico and Navajo Dam is relatively stable with few secondary channels.

From Lake Powell to Navajo Dam, the mean gradient of the San Juan River is 1.67 m/km. Examined in 30 km increments, river gradient ranges from 1.24 to 2.41 m/km but locally (i.e., <30 km reaches) can be as high as 3.5 m/km. Between Shiprock and Bluff, San Juan River substrate is primarily sand mixed among some cobble. The proportion of sand is greatest in the downstream most reaches and declines along an upstream gradient. From Farmington to Navajo Dam, the San Juan River substrate is dominated by embedded cobble. Although less embedded, cobble is also the most common substrate between Shiprock and Farmington.

Except in canyon-bound reaches, the river is bordered by nonnative salt cedar, *Tamarix chinensis,* and Russian olive, *Elaeagnus angustifolia,* and native cottonwood, *Populus fremontii,* and willow, *Salix* sp. Nonnative woody plants dominated nearly all sites and resulted in heavily stabilized banks. Cottonwood and willow accounted for less than 15% of the riparian vegetation.

The characteristic annual hydrographic pattern in the San Juan River is typical of rivers in the American Southwest with large flows during spring snowmelt, followed by low summer, autumn, and winter base flows. Summer and early autumn base flows are frequently punctuated by convective storm-induced flow spikes. Prior to closure of Navajo Dam, about 73% of the total annual San Juan River drainage discharge (based on USGS Gauge # 09379500; Bluff, Utah) occurred during spring runoff (1 March through 31 July). Median daily peak discharge during spring runoff was 10,400 cfs (range = 3,810 to 33,800 cfs). Although flows resulting from summer and autumn storms contributed a comparatively small volume to total annual discharge, the magnitude of storm-induced flows exceeded the peak snowmelt discharge about 30% of the years, occasionally exceeding 40,000 cfs (mean daily discharge). Both the magnitude and frequency of these storm induced flow spikes are greater than those recorded in the Green or Colorado rivers.

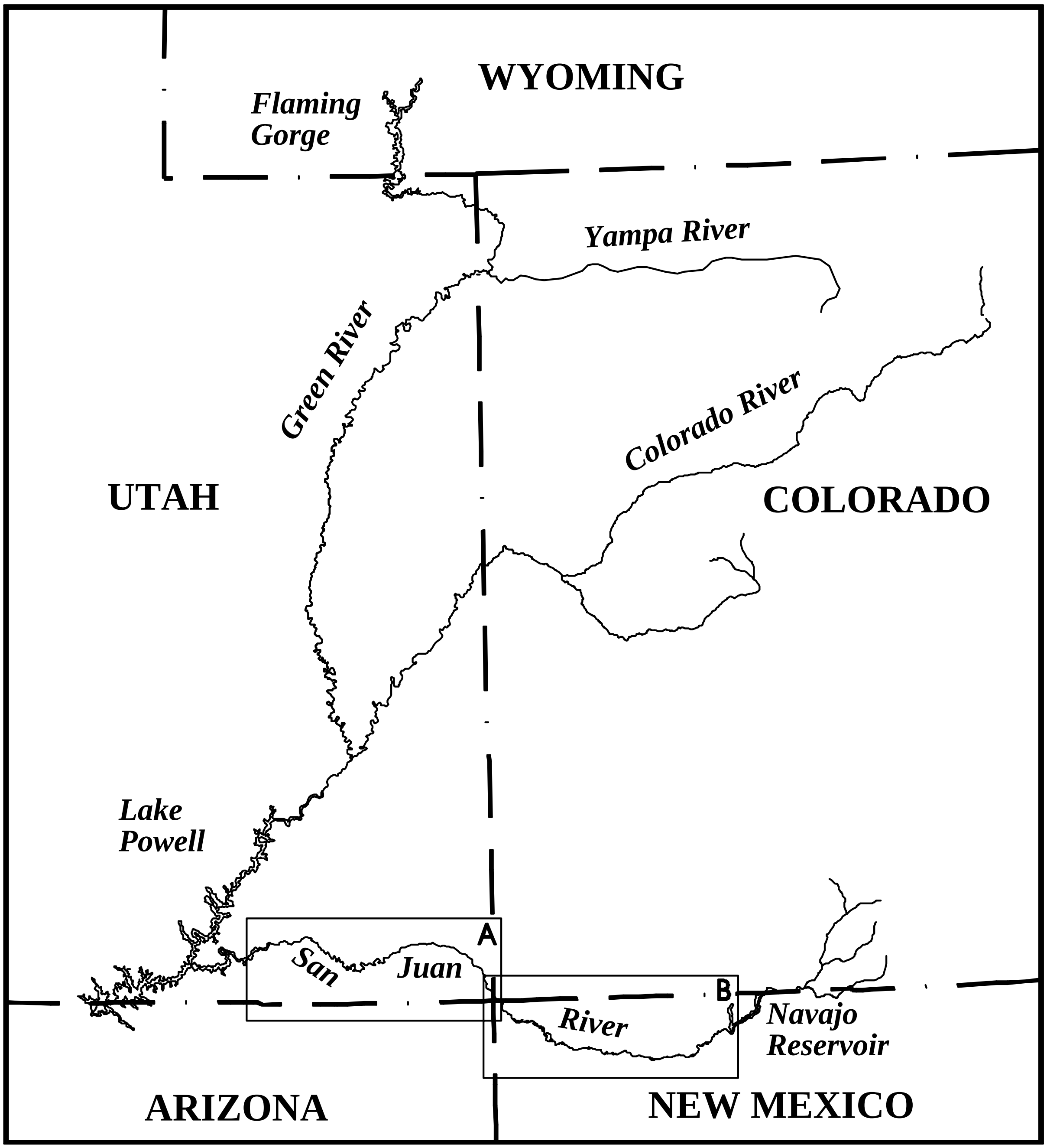

Figure 1. Location of the San Juan River within the upper Colorado River basin.

Operation of Navajo Dam altered the annual discharge pattern of the San Juan River. The natural flow of the Animas River ameliorated some aspects of regulated discharge by augmenting spring discharge. Regulation resulted in reduced magnitude and increased duration of spring runoff in wet years and substantially reduced magnitude and duration of spring flow during dry years. Overall, flow regulation by operation of Navajo Dam has resulted in post-dam peak spring discharge averaging about 54% of pre-dam values. Conversely, post-dam base flow increased markedly over pre-dam base flows.

Since 1992, Navajo Dam has been operated to mimic a “natural” San Juan River hydrograph with the volume of release during spring linked to the amount of precipitation recorded during the preceding winter. Thus in years with high spring snowmelt, reservoir releases were “large” and “small” in low runoff years. Base flows since 1992 were typically greater than during pre-dam years but less than those between 1964-1991.

The primary study area for most investigations conducted under the auspices of the San Juan River Seven Year Research Program, including that reported herein, were accomplished in the mainstem San Juan River and its immediate vicinity between Navajo Dam and Lake Powell. There is considerable human activity within the floodplain of the San Juan River between Shiprock and Navajo Dam. Irrigated agriculture is practiced throughout this portion of the San Juan River Valley and adjacent uplands. Much of the river valley not devoted to agriculture (crop production and grazing) consists of small communities (e.g., Blanco and Kirtland) and several larger towns (e.g., Bloomfield and Farmington). The Animas River Valley is similarly developed. Small portions of the river valley and uplands from Shiprock to Bluff are farmed with dispersed livestock grazing as the primary land use. In the vicinity of Montezuma Creek and Aneth, petroleum extraction occurs in the floodplain and adjacent uplands. There are few human-caused modifications of the system from Bluff to Lake Powell.

A multivariate analysis of a suite of geomorphic features of the San Juan drainage was performed to segregate the river into distinct geomorphic reaches, enhance comparison between studies, and to provide a common reference for all research. This effort (Bliesner and Lamarra, 1999) resulted in the identification of eight reaches of the San Juan River between Lake Powell and Navajo Dam. A brief characterization of each reach (from downstream to upstream) follows.

Reach 1 (RM 0 to 16, Lake Powell confluence to near Slickhorn Canyon) has been greatly influenced by fluctuating reservoir levels of Lake Powell and its backwater effect. Fine sediment (sand and silt) has been deposited to a depth of about 12 m in the lowest end of this reach since the reservoir first filled in 1980. This deposition of suspended sediment into the delta-like environment of the river/reservoir transition makes it the lowest-gradient reach in the river. This portion of the river is canyon bound with an active sand bottom. Although an abundance of low-velocity habitat is present at certain flows, it is highly ephemeral, being influenced by both river flow and Lake Powell’s elevation.

Reach 2 (RM 17 to 67, near Slickhorn Canyon to confluence with Chinle Creek) is also canyon bound but is upstream of the influence of Lake Powell. The gradient in this reach is greater than in either adjacent reach and the fourth highest in the system. The channel is primarily bedrock confined and influenced by debris fans at ephemeral tributary mouths. Riffle-type habitat dominates, and the only major rapids in the San Juan River occur in this reach. Backwater abundance is low in this reach, usually occurring in association with debris fans.

Reach 3 (RM 68 to 105, Chinle Creek to Aneth, Utah) is characterized by higher sinuosity and lower gradient (second lowest) than the other reaches, a broad floodplain, multiple channels, high island count, and high percentage of sand substrate. While this reach has the second greatest density of backwater habitats after peak spring runoff, it is extremely vulnerable to change during summer and autumn storm events. After these storm events, this reach may have the second lowest density o fbackwaters of the eight reaches. The active channel distributes debris piles throughout the reach following spring runoff, leading to the nickname “Debris Field”.

Reach 4 (RM 106 to 130, Aneth, Utah, to below “the Mixer”) is a transitional zone between the upper cobble substrate-dominated reaches and the lower sand substrate-dominated reaches.

Sinuosity is moderate compared with other reaches, as is gradient. Island area is higher than in Reach 3 but lower than in Reach 5, and the valley is narrower than in either adjacent reach. Backwater habitats are low overall in this reach (third lowest among reaches) and there is little clean cobble.

Reach 5 (RM 131 to 154, the Mixer to just below Hogback Diversion) is predominantly multi-channeled with the largest total wetted area and greatest secondary channel area of any of the reaches. Secondary channels in this section tend to be longer and more stable (but fewer) than in Reach 3. Riparian vegetation is more dense in this reach than in lower reaches but less dense than in upper reaches. Cobble and gravel are more common in channel banks than sand, and clean cobble areas are more abundant than in lower reaches. This is the lowermost reach containing a diversion dam (Cudei). Backwaters and spawning bars in this reach are much less subject to perturbation during summer and fall storm events than are the lower reaches.

Reach 6 (RM 155 to 180, below Hogback Diversion to confluence with the Animas River) is predominantly a single channel, with 50% fewer secondary channels than Reaches 3, 4, or 5. Cobble and gravel are the dominant substrata with cobble bars containing clean interstitial spaces being most abundant in this reach. There are four diversion dams that may impede fish passage in this reach. Backwater habitat abundance is low in this reach, with only Reach 2 containing fewer of these habitats. The channel has been altered by dike construction in several areas to control lateral channel movement and over-bank flow.

Reach 7 (RM 181 to 213, Animas River confluence to between Blanco and Archuleta, New Mexico) is similar to Reach 6 in terms of channel morphology. The river channel is very stable, consisting primarily of embedded cobble substrate as a result of controlled releases from Navajo Dam. In addition, much of the river bank has been stabilized and/or diked to control lateral movement of the channel and over-bank flow. Water temperature is influenced by the hypolimnetic release from Navajo Dam and is colder during the summer and warmer in the winter than that of the river below the Animas confluence.

Reach 8 (RM 213 to 224, between Blanco and Archuleta and Navajo Dam) is the most directly influenced by Navajo Dam, which is situated at its uppermost end (RM 224). This reach is primarily a single channel, with only four to eight secondary channels, depending on the flow. Cobble is the dominant substrate type, and because lateral channel movement is less confined in this reach, some loose, clean cobble sources are available from channel banks. In the upper end of the reach, just below Navajo Dam, the channel has been heavily modified by excavation of material used in dam construction. In addition, the upper 10 km of this reach above Gobernador Canyon are essentially sediment free, resulting in the clearest water of any reach. Because of Navajo Dam, this area experiences much colder summer and warmer winter water temperatures. These cool, clear water conditions have allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of native species in the uppermost portion of the reach.

The study area in 2003 encompassed reaches 1 through 5 (Figure 2). Three Colorado pikeminnow larval fish collection trips were taken between 9 July and 19 September 2003. Each trip began at river mile 141.6 (Cudei, New Mexico) and ended at river mile 2.9 (Clay Hills, Utah).

Objectives

The primary objective of this study is to determine if Colorado pikeminnow reproduction occurred in the San Juan River (during 2003) and the relative level of any such effort. Additional goals were to determine the spawning periodicity of catostomids between early-July and mid-September and provide comparative analysis of the reproductive effort of San Juan River catostomids. This document reports results of the 2003 larval Colorado pikeminnow sampling effort.

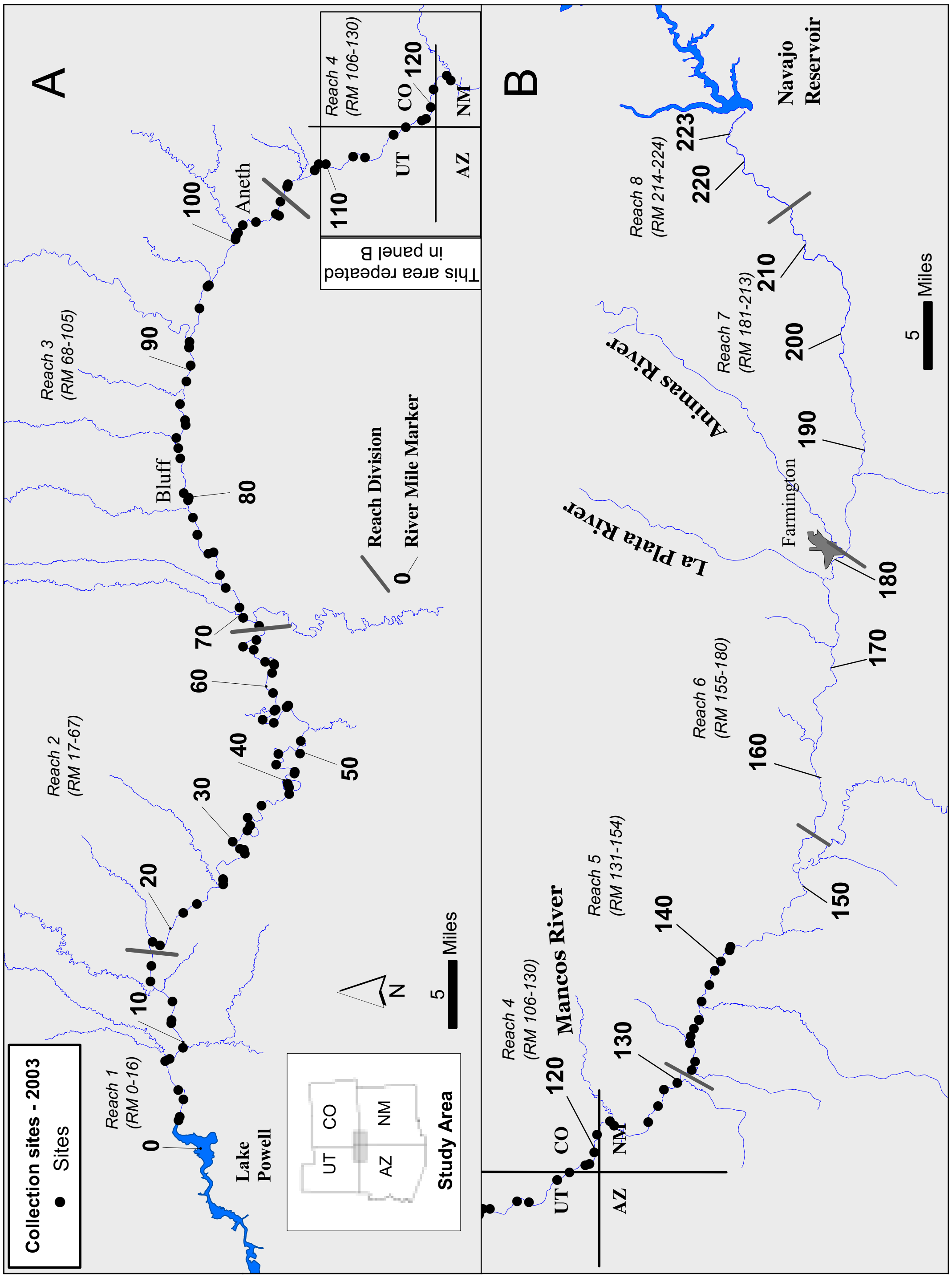

Figure 2. Distribution map of localities sampled during 2003.

Methods

Access to the river and sampling localities was gained through the use a 16' inflatable raft that transported both personnel and collecting gear. There was not a predetermined number of samples per river mile nor geomorphic reach for this study. Instead, an effort was made to collect in as many suitable larval fish habitats as possible within the river reach being sampled. Previous San Juan River investigations have clearly demonstrated that larval fish most frequently occur and are most abundant in low velocity habitats such as isolated pools, backwaters, and secondary channels.

Sampling efforts for larval fish concentrated on low velocity habitats using small mesh seines (1 m x 1 m x 0.8 mm). Meso-habitat type, length, maximum depth, and substrate were recorded for each sample. Water quality measurements were also obtained and recorded through the use of a multi-parameter YSI-85 water quality meter. For seine samples, the length of each seine haul was determined in addition to the number of seine hauls per site. A minimum of one digital photograph was also taken at each of the sampling localities.

All retained specimens were placed in plastic bags (Whirl-paks) containing a solution of 10% formalin and a tag inscribed with unique alpha-numeric code that was also recorded on the field data sheet. Samples were returned to the laboratory where they were sorted, specimens identified to species, enumerated, measured (minimum and maximum size [mm SL] for each species at each site), transferred to 70% ethyl alcohol, and catalogued in the Division of Fishes of the Museum of Southwestern Biology (MSB) at the University of New Mexico (UNM). Scientific and common names of fishes that are used in this report follow Robins et al. (1991) while six letter codes for species are derived from the first three letters of the genus followed by the first three letters of the species (Table 2). Common names, arranged in phylogenetic order, are presented in tables in this report.

River Mile was determined to tenth of a mile using the 2003 standardized map set produced for the San Juan River Basin Recovery Implementation Program and used to designate the location of sampling sites. In addition, geographic coordinates were determined at each site with a Garmin Navigation Geographic Positioning System (GPS) Instrument and were recorded in Universal Transverse Mercator (UTM) Zone 12 (NAD27). In instances where coordinates could not be obtained due to poor GPS satellite signal, coordinates were determined upon return to the lab using a Geographic Information System based on the recorded river mile.

Specimens were identified to species by MSB personnel trained in larval fish identification. Specimens whose species-specific identity was questionable were forwarded to Darrel E. Snyder (Larval Fish Laboratory, Colorado State University) for review.

An electronic copy of the 2003 fish collection data will be formatted for inclusion in the San Juan River integrated database being developed at UNM.

This study was annually initiated in mid-summer and completed in late-summer. Daily mean discharge during the study period was determined from U.S. Geological Survey Gauge (# 09379500) at Bluff, Utah (Figure 3).

Results

2003 Survey

There were 180 samples taken at 160 unique sites during the 2003 Colorado pikeminnow larval fish survey (Figure 4). All except one of the samples produced fish, yielding 70,353 specimens representing six families and eleven species (Table 3). Three separate trips were made between 9 July and 19 September 2003 starting at river mile 141.5 (Cudei, New Mexico) and ending at river mile 2.9 (Clay Hills, Utah). There were 95 more samples taken in 2003 than in 2002 with the total area sampled in 2003 nearly double that of 2002 (6,235 m^2 and 3,261 m^2 respectively). However, 2003 produced 20,166 fewer fish than were collected in 2002 (70,353 and 90,518 respectively). This represents a 22.3%

Table 2. Scientific and common names and species codes of fish collected from the San Juan River. Asterisk (*) indicates species collected in previous years, but not in 2003.

Scientific Name	Common Name	Code
Order Cypriniformes		
Family Cyprididae	carps and minnows	
Cyprinella lutrensis	red shiner	(CYPLUT)
*Cyprinus carpio**	common carp	(CYPCAR)
*Gila robusta**	roundtail chub	(GILROB)
Pimephales promelas	fathead minnow	(PIMPRO)
Ptychocheilus lucius	Colorado pikeminnow	(PTYLUC)
Rhinichthys osculus	specked dace	(RHIOSC)
Family Catostomidae	suckers	
Catostomus (Pantosteus) discobolus	bluehead sucker	(CATDIS)
Catostomus latipinnis	flannelmouth sucker	(CATLAT)
*Xyrauchen texanus**	razorback sucker	(XYRTEX)
Order Siluriformes		
Family Ictaluridae	bullhead catfishes	
Ameiurus melas	black bullhead	(AMEMEL)
Ictalurus punctatus	channel catfish	(ICTPUN)
Order Salmoniformes		
Family Salmonidae	trouts	
*Oncorhynchus nerka**	kokanee salmon	(ONCNER)
Order Atheriniformes		
Family Cyprinodontidae	killifishes	
Fundulus zebrinus	plains killifish	(FUNZEB)
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(GAMAFF)
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(LEPCYA)
*Lepomis macrochirus**	bluegill	(LEPMAC)
Micropterus salmoides	largemouth bass	(MICSAL)

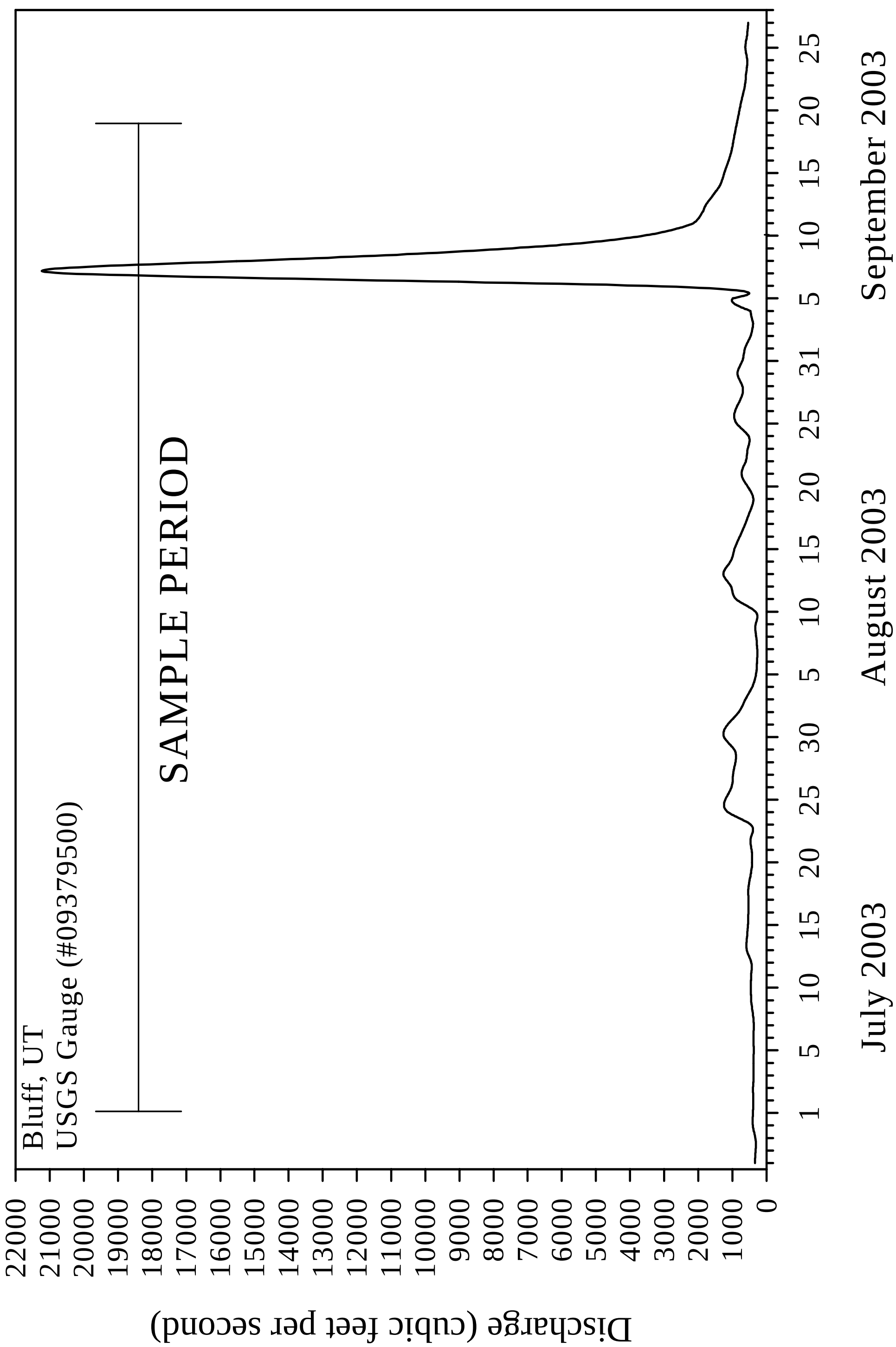

Figure 3. Hydrograph of the San Juan River at Bluff, Utah during the 2003 sampling period.

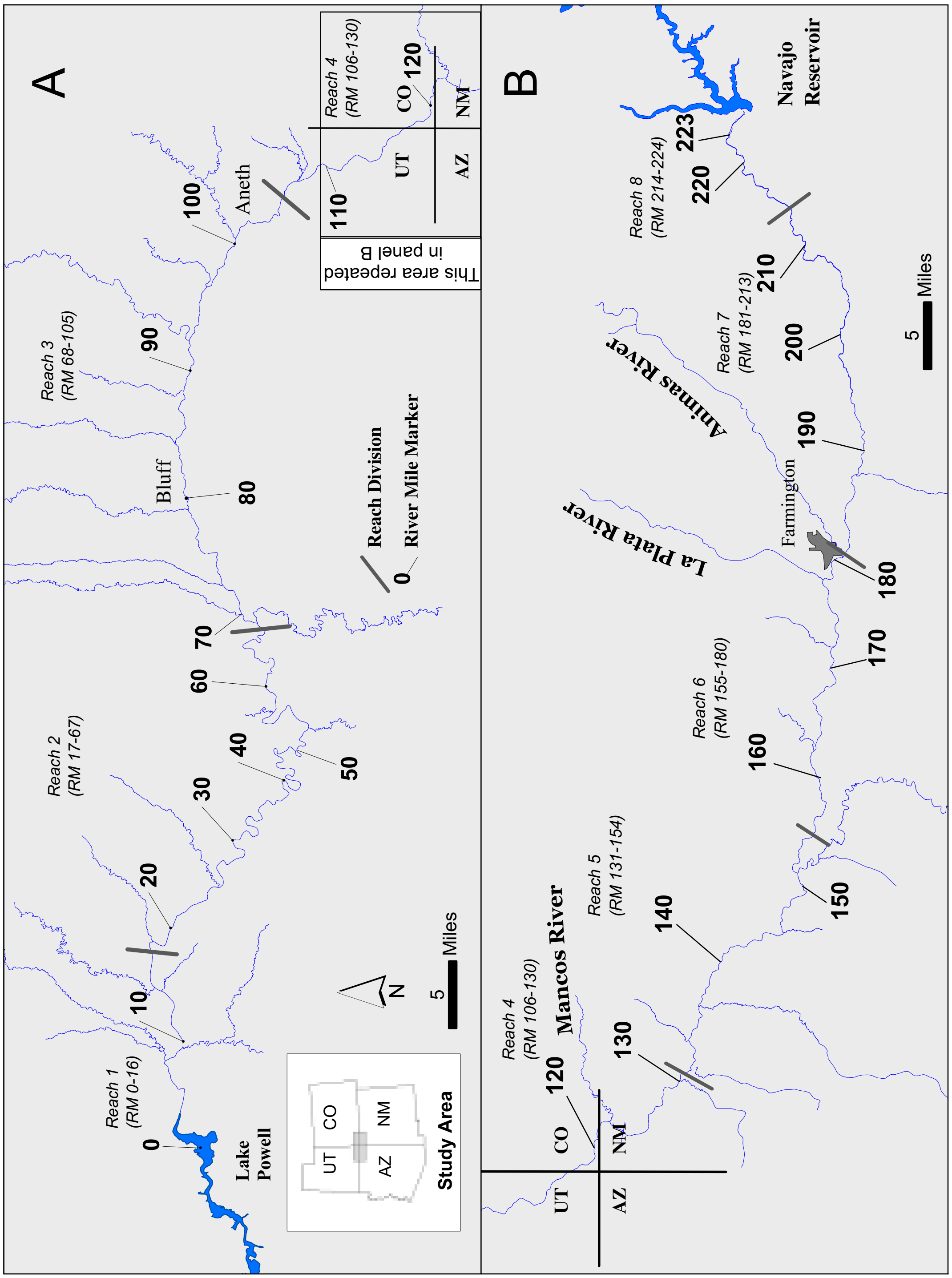

Figure 4. Map of the San Juan River study area.

Table 3. Summary of the 2003 San Juan River larval Colorado pikeminnow project fish collections. Effort=6235.1 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	53,253	75.7	177	98.3
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	12,932	18.4	142	78.9
Colorado pikeminnow	N	1	*	1	0.5
speckled dace	N	1,384	2.0	108	60.0
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	84	0.1	37	20.6
bluehead sucker	N	628	0.9	55	30.6
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	57	0.1	11	6.1
channel catfish	I	349	0.5	78	43.3
KILLIFISHES					
plains killifish	I	143	0.2	33	18.3
LIVEBEARERS					
western mosquitofish	I	1,325	1.9	88	48.9
SUNFISHES					
green sunfish	I	192	0.3	2	1.1
bluegill	I	-	-	-	-
largemouth bass	I	5	*	4	2.2
TOTAL		70,353			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=180 samples.

* Value is less than 0.05%

23.3 percent decrease in fish collected between 2002 and 2003. Red shiner was the numerically dominant species accounting for 75.7% of all fish collected and was present in 177 of the 179 collections that produced fish. Fathead minnow was the second most dominant species collected and accounted for 18.4% of all fish collected. Combined, non-native fish accounted for 97.0% of fish collected, with only 3.0% of all specimens collected being native fish. Colorado pikeminnow, speckled dace, flannelmouth sucker and bluehead sucker were the four native fish species collected. Of the native fish collected, speckled dace was the most frequently encountered fish being present in 108 collections, while Colorado pikeminnow was the least encountered fish, occurring in only one sample.

Trip 1

The first trip took place between 9 and 17 July 2003 (Figure 5). This trip produced more fish than any other trip (n=34,758) and accounted for 49.4% of all fish collected during the course of this study. Red shiner accounted for 80.6% of the total catch and was present in all 60 of the collections made (Table 4). Fathead minnow accounted for 15.1% of the total catch and was present in all but nine of the collections. This was the only trip in which red shiner was over 80% of the total catch (Figure 6) This trip also yielded the highest percent frequency of occurrence for fathead minnow and bluehead sucker (85.0% and 53.3% respectively). Native fish accounted for 3.3% of the total catch, with this trip being the only one in which bluehead sucker accounted for greater that 1% of the total catch. A total of 2,082 m^2 were sampled, with the catch per unit effort (CPUE) for this trip being 1,670 fish per 100 m^2. This was the highest CPUE of any of the three trips. Trip 1 was also the most productive trip for both reaches 1 and 5 and was the only trip to produce a Colorado pikeminnow (n=1 at 201 mm SL). Nearly 86% and 67% of fish collected in reaches 1 and 5, respectively, were collected during trip 1.

Trip 2

The second trip began on 4 August (Figure 7) and was interrupted on 10 August 2003 at Mexican Hat, Utah, due to low flow conditions (280 cfs at Bluff, Utah). Subsequent rain events raised the flow sufficiently to allow the remaining section of river between Mexican Hat and Clay Hills to be sampled the following week between 18 and 21 August 2003. A total of 61 samples yielding 27,461 specimens were collected during this trip. Red shiner was again the numerically dominant species followed by fathead minnow. Red shiner accounted for 69.5% of the total catch, the lowest value for any of the three trips (Table 5). Fathead minnow accounted for 24.3% of the total catch, the highest value for any of the three trips. This trip also produced the highest percent frequency of occurrence (78.7%) for fathead minnow. Native fish accounted for 2.4% of the total catch for this trip, the lowest combined total for native fish. This trip was the only trip in which green sunfish were collected. Of the 192 green sunfish collected, 191 were taken from a single isolated pool at river mile 38.8. Trip 2 also yielded the highest numbers of black bullhead and channel catfish (51 and 238 respectively). A total of 2,025 m^2 of habitat was sampled, with a CPUE of 1,356 fish per 100 m^2 for trip 2. Trip 2 was also the most productive trip for reaches 2, 3 and 4, with half of all fish collected from these reaches combined collected during trip 2.

Trip 3

Trip 3 began on 5 September (Figure 8) and was interrupted on 9 September 2003 at Bluff, Utah due to a major flood event that began on the evening of the 9th. Mean daily discharge at Bluff, Utah peaked at 20,600 cfs on 10 September 2003. The trip was continued on 16 September, beginning at Bluff, Utah and concluded on 19 September 2003 at Clay Hills, Utah. While red shiner was again the dominant species present (75.5% of the total catch), this was the only trip in which red shiner was not collected in every sample (Table 6). Two of the 59 samples contained no red shiner, with one sample producing no fish at all. Native fish accounted for 3.4% of the total catch, the highest proportion of native fish during the course of this study. Speckled dace accounted for 3.1% of the total catch, (the highest value for any of the three trips), while flannelmouth and bluehead sucker accounted for 0.2% and 0.1% of the total catch respectively. Trip 3 had the lowest CPUE of any of the trips (382 fish per 100 m^2) and was the least productive trip for all five reaches sampled.

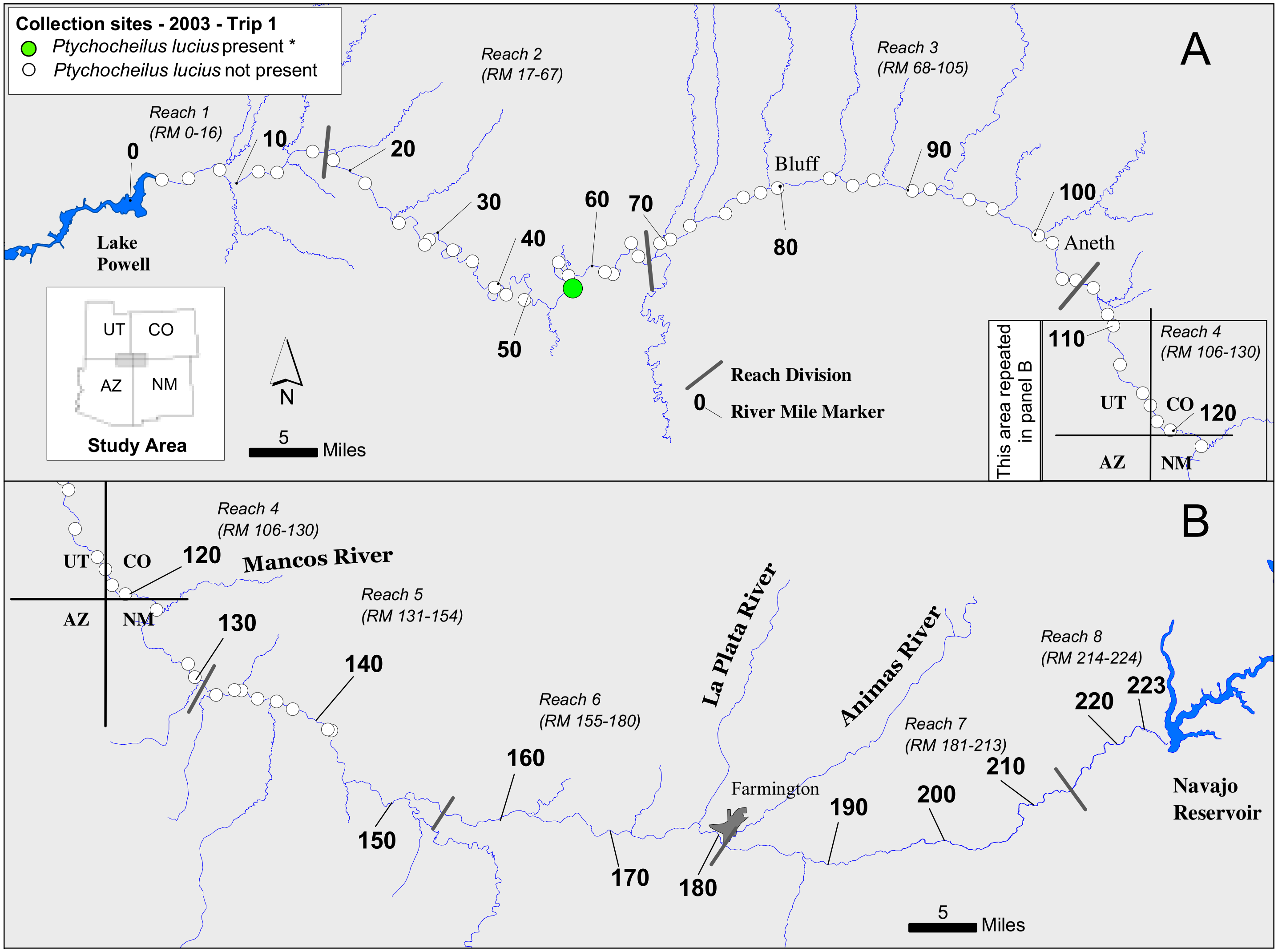

Figure 5. Map of the localities sampled during Trip 1 (9 - 17 July 2003). No larval Colorado pikeminnow were collected. *A single sub-adult (201 mm SL) specimen was collected.

Table 4. Summary of Trip 1 (9 - 17 July, 2003) San Juan River larval Colorado pikeminnow project collections. Effort = 2082.2 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	28,028	80.6	60	100.0
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	5,265	15.1	51	85.0
Colorado pikeminnow	N	1	*	1	1.7
speckled dace	N	625	1.8	36	60.0
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	39	0.1	14	23.3
bluehead sucker	N	500	1.4	32	53.3
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	1	*	1	1.7
channel catfish	I	8	*	4	6.7
KILLIFISHES					
plains killifish	I	3	*	3	5.0
LIVEBEARERS					
western mosquitofish	I	284	0.8	22	36.7
SUNFISHES					
green sunfish	I	-	-	-	-
bluegill	I	-	-	-	-
largemouth bass	I	4	*	3	5.0
TOTAL		34,758			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=60 samples.

* Value is less than 0.05%

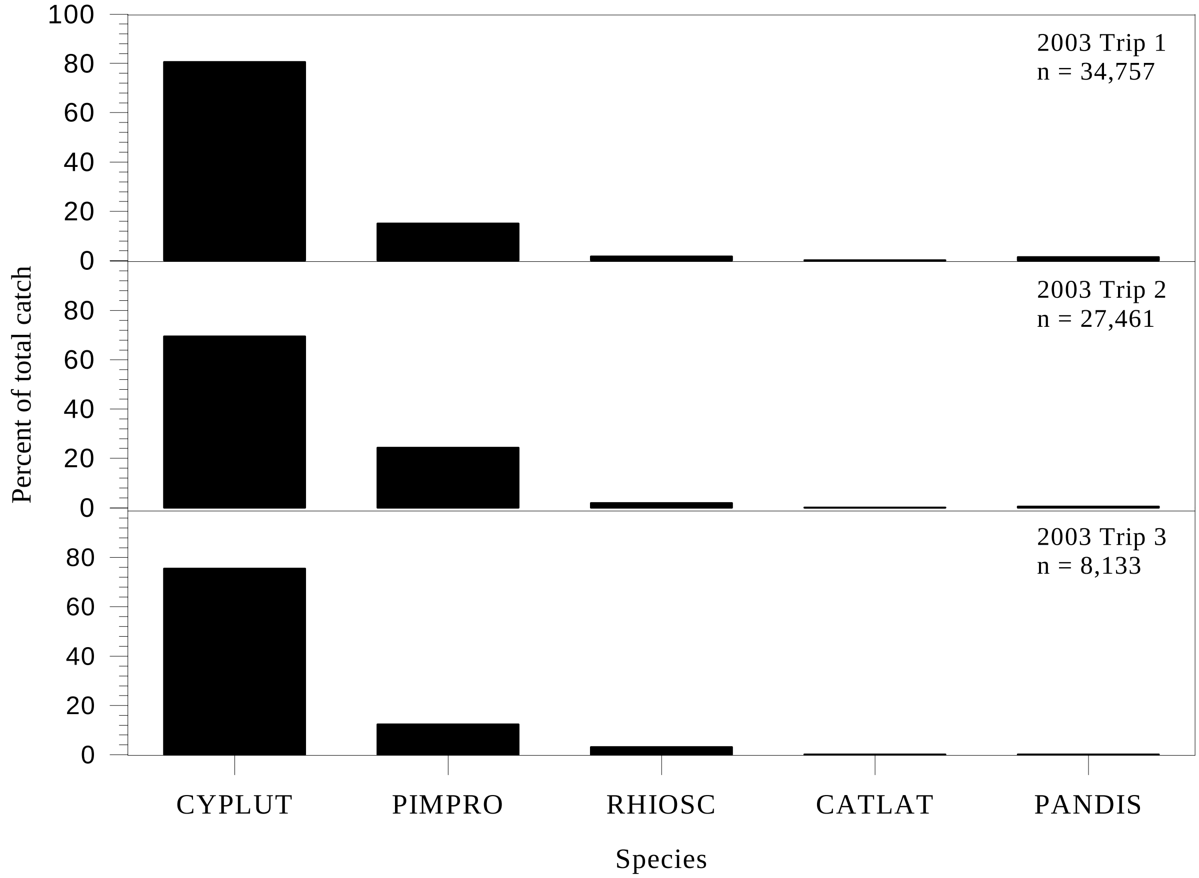

Figure 6. Ichthyofaunal composition of 2003 sampling efforts by trip.

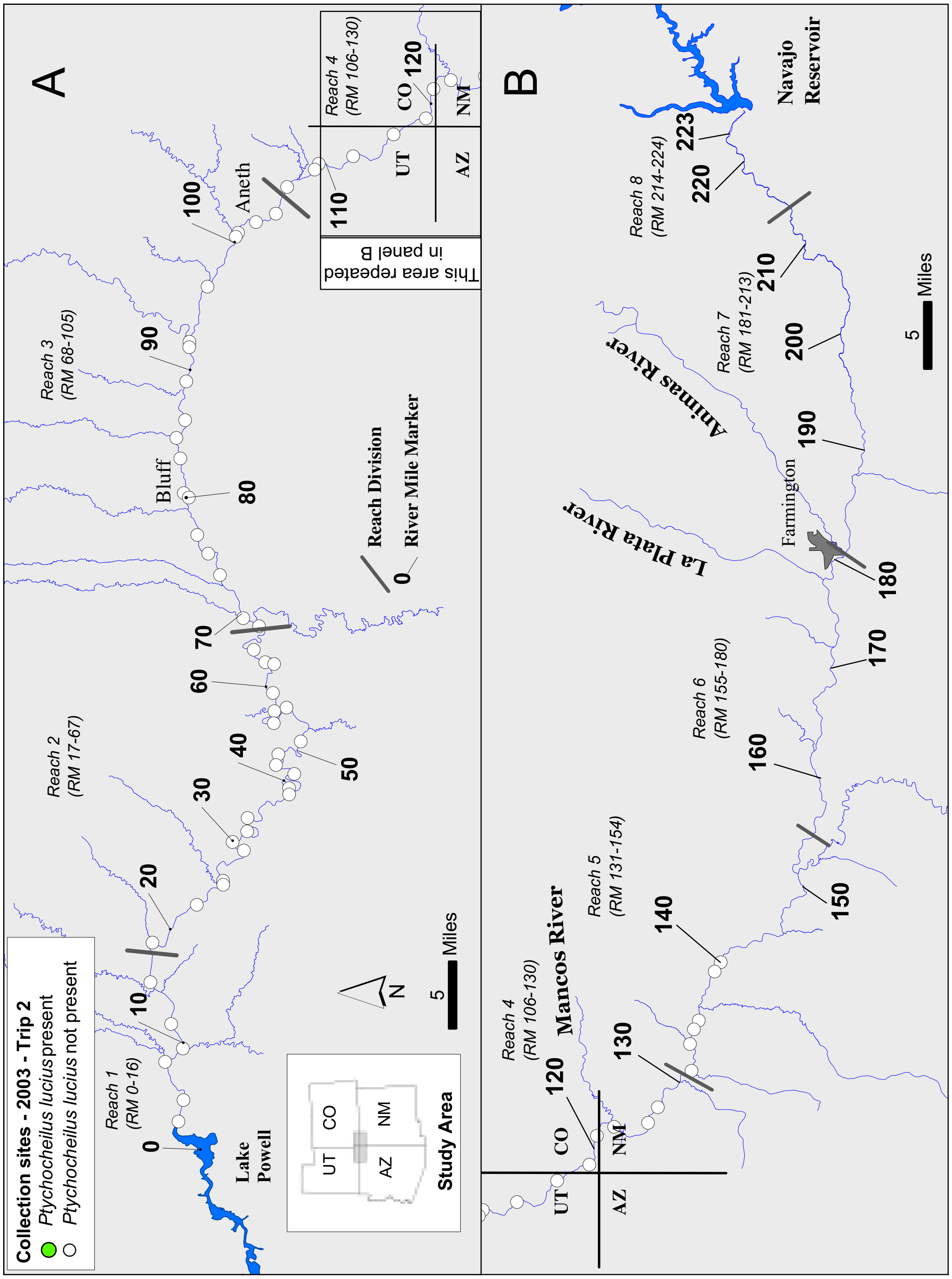

Figure 7. Map of localitites sampled during Trip 2 (4 - 10 and 18 - 21 August 2003). No larval Colorado pikeminoow were collected.

Table 5. Summary of Trip 2 (4 - 10 and 18 - 21 August, 2003) San Juan River larval Colorado pikeminnow project fish collections. Effort= 2025.1 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	19,084	69.5	61	100.0
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	6,667	24.3	48	78.7
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	509	1.9	41	67.2
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	26	0.1	14	23.0
bluehead sucker	N	117	0.4	17	27.9
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	51	0.2	7	11.5
channel catfish	I	238	0.9	42	68.9
KILLIFISHES					
plains killifish	I	48	0.2	13	21.3
LIVEBEARERS					
western mosquitofish	I	529	1.9	33	54.1
SUNFISHES					
green sunfish	I	192	0.7	2	3.3
bluegill	I	-	-	-	-
largemouth bass	I	-	-	-	-
TOTAL		27,461			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=61 samples.

* Value is less than 0.05%

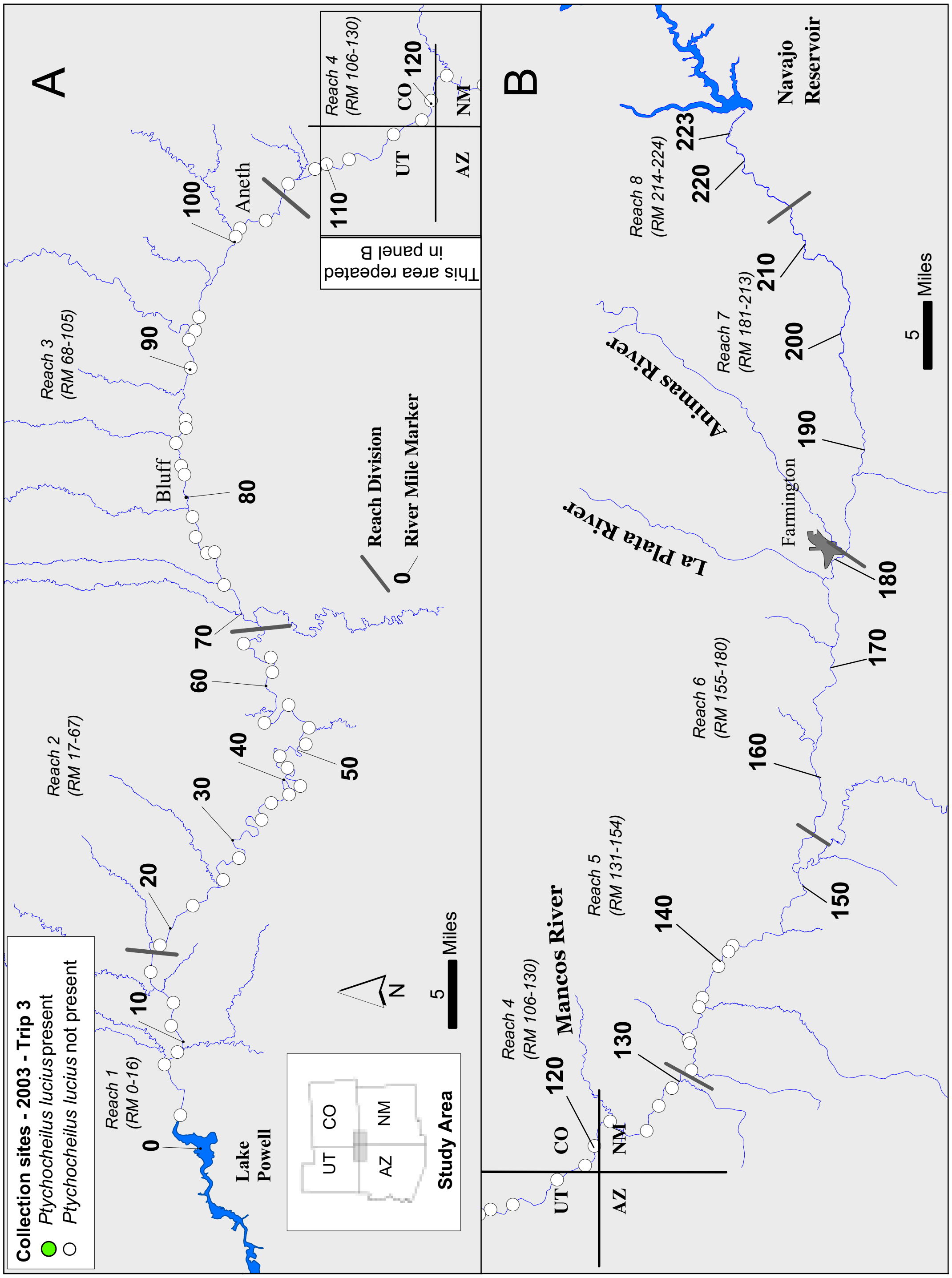

Figure 8. Map of localities sampled during Trip 3 (5 - 9 and 16 - 19 September 2003). No larval Colorado pikeminnow were collected.

Table 6. Summary of Trip 3 (5 - 9 and 16 - 19 September, 2003) San Juan River larval Colorado pikeminnow project fish collections. Effort = 2127.8 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	6,141	75.5	56	94.9
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	1,000	12.3	43	72.9
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	250	3.1	31	52.5
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	19	0.2	9	15.3
bluehead sucker	N	11	0.1	6	10.2
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	5	0.1	3	5.1
channel catfish	I	103	1.3	32	54.2
KILLIFISHES					
plains killifish	I	92	1.1	17	28.8
LIVEBEARERS					
western mosquitofish	I	512	6.3	33	55.9
SUNFISHES					
green sunfish	I	-	-	-	-
bluegill	I	-	-	-	-
largemouth bass	I	1	*	1	1.7
TOTAL		8,134			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=59 samples.

* Value is less than 0.05%

Reach Analysis

Reach 1

There were 18 samples taken in reach 1 yielding 15,152 specimens (Table 7). Nearly 86% of all fish collected in this reach were collected during the July sampling trip. Red shiner accounted for 98.8% of the total catch, the highest percent of total for red shiner in any of the five reaches (Figure 9). Reach 1 had the lowest species diversity (n=8) of any of the reaches and was the only reach that did not produce plains killifish. A total of 28 native fish were collected in reach 1, the lowest number of native fish for any of the five reaches. However, reach 1 had the highest CPUE of any of the reaches (2,174 fish per 100 m^2) with 696.9 m^2 of area sampled. It should be noted that no samples were taken below Clay Hills, Utah (river mile 2.9). Therefore, during the course of this study, 14.1 miles of river were sampled representing 82.9% of reach 1.

Reach 2

Reach 2 produced fewer fish than any other reach, (n=6,438) and was the only reach to generate a sample in which no fish were collected (Table 8). However, reach 2 was the only reach to produce a Colorado pikeminnow. Reach 2 had the lowest CPUE of any of the reaches at 416 fish per 100 m^2. Reach 2 produced more green sunfish than any other reach (n=191) and had the highest percent of total for both green sunfish and channel catfish (3.0% and 2.1% respectively) [Table 8]. Speckled dace accounted for 1.1% of the total, while both flannelmouth and bluehead sucker each accounted for 0.2% of the total catch. Reach 2 was also the only reach to produce both green sunfish and largemouth bass (the only two centrachid species collected during the course of this study). Red shiner was the numerically dominant species comprising 87.6% of the total catch.

Reach 3

A total of 53 samples were taken in reach 3 generating 20,664 specimens (Table 9). This was the largest number of specimens generated for any of the reaches. Despite such a large number of specimens being collected, reach 3 had the second lowest CPUE at 1,023 fish per 100 m^2. Reach 3 yielded the highest numbers for both flannelmouth and bluehead sucker (59 and 384 respectively), as well as channel catfish, plains killifish, and western mosquitofish (138, 91, and 673 respectively). The percent frequency of occurrence for fathead minnow was 94.3%, the highest of any of the reaches sampled. Native fish accounted for 4.8% of the total catch, also the highest value of any of the five reaches.

Reach 4

Reach 4 produced the second largest number of specimens (n=18,573) and had the second highest CPUE at 1,635 fish per 100 m^2 (Table 10). While red shiner was the numerically dominant species it accounted for only 61.7% of the total catch, the lowest value for any of the reaches. Conversely, fathead minnow accounted for 32.6% of the total catch, the highest value for any of the five reaches. More speckled dace were collected in this reach than any other reach (n=610), and speckled dace also made up 3.3% of the total catch, which was the highest percentage of any of the reaches. Reach 4 was one of two reaches that produced both black bullhead and channel catfish, as well as green sunfish.

Reach 5

A total of 22 samples were taken in reach five yielding 9,526 specimens. This was the second lowest number of specimens taken from any of the reaches, however it should be noted that only the section of reach 5 between river mile 141.5 (Cudei, New Mexico) and river mile 131 was sampled. This represents 43.8% of reach 5. Reach 5 had a CPUE of 1,141 fish per 100 m^2. Red shiner was again the numerically dominant species, being present in all but one of the samples (Table 11). Reach 5 was one of two reaches in which red shiner was not present in every sample taken. Reach 5 also produced both black bullhead and channel catfish and had the highest percent of total (4.1%) for western mosquito fish of any of the reaches.

Table 7. Summary of Reach 1 (RM 0-16) 2003 San Juan River larval Colorado pikeminnow project fish collections. Effort = 696.9 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	14,968	98.8	18	100.0
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	101	0.7	15	83.3
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	20	0.1	7	38.9
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	5	*	4	22.2
bluehead sucker	N	2	*	2	11.1
razorback sucker	N	-	-	-	-
undetermined Catostomidae	N	-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	-	-	-	-
channel catfish	I	27	0.2	7	38.9
KILLIFISHES					
plains killifish	I	-	-	-	-
LIVEBEARERS					
western mosquitofish	I	27	0.2	5	27.8
SUNFISHES					
green sunfish	I	-	-	-	-
bluegill	I	-	-	-	-
largemouth bass	I	1	*	1	5.6
TOTAL		15,151			

1 N = native; I = introduced
2 Frequency and % frequency of occurrence are based on n=18 samples.

* Value is less than 0.05%

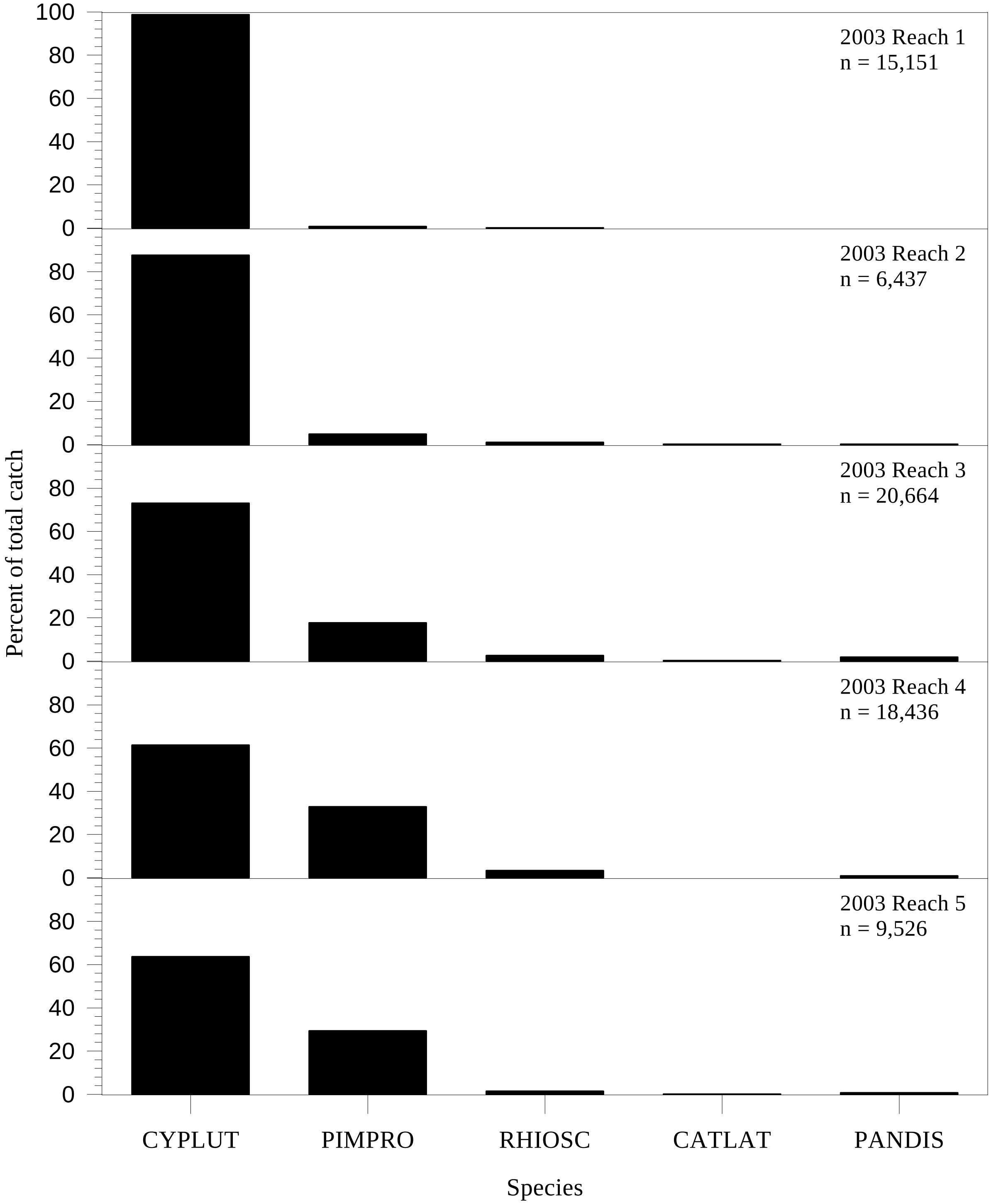

Figure 9. Icthyofaunal compositon of 2003 sampling efforts by reach.

Table 8. Summary of Reach 2 (RM 17-67) 2003 San Juan River larval Colorado pikeminnow project fish collections. Effort = 1546.7 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	5,639	87.6	53	96.4
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	314	4.9	30	54.5
Colorado pikeminnow	N	1	*	1	1.8
speckled dace	N	70	1.1	25	45.5
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	10	0.2	6	10.9
bluehead sucker	N	13	0.2	7	12.7
razorback sucker	N	-	-	-	-
undetermined Catostomidae	N	-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	-	-	-	-
channel catfish	I	134	2.1	26	47.3
KILLIFISHES					
plains killifish	I	3	*	2	3.6
LIVEBEARERS					
western mosquitofish	I	62	1.0	15	27.3
SUNFISHES					
green sunfish	I	191	3.0	1	1.8
bluegill	I	-	-	-	-
largemouth bass	I	1	*	1	1.8
TOTAL		6,438			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=55 samples.

* Value is less than 0.05%

Table 9. Summary of Reach 3 (RM 68-105) 2003 San Juan River larval Colorado pikeminnow project fish collections. Effort = 2020.4 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	15,109	73.1	53	100.0
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	3,667	17.7	50	94.3
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	539	2.6	40	75.5
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	59	0.3	20	37.7
bluehead sucker	N	384	1.9	22	41.5
razorback sucker	N	-	-	-	-
undetermined Catostomidae	N	-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	2	*	1	1.9
channel catfish	I	138	0.7	31	58.5
KILLIFISHES					
plains killifish	I	91	0.4	17	32.1
LIVEBEARERS					
western mosquitofish	I	673	3.3	33	62.3
SUNFISHES					
green sunfish	I	-	-	-	-
bluegill	I	-	-	-	-
largemouth bass	I	2	*	1	1.9
TOTAL		20,664			

1 N = native; I = introduced
2 Frequency and % frequency of occurrence are based on n=53 samples.

* Value is less than 0.05%

Table 10. Summary of Reach 4 (RM 106-130) 2003 San Juan River larval Colorado pikeminnow project fish collections. Effort = 1136.2 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	11,465	61.7	32	100.0
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	6,048	32.6	29	90.6
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	610	3.3	25	78.1
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	5	*	3	9.4
bluehead sucker	N	161	0.9	17	53.1
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	44	0.2	7	21.9
channel catfish	I	37	0.2	9	28.1
KILLIFISHES					
plains killifish	I	31	0.2	9	28.1
LIVEBEARERS					
western mosquitofish	I	171	0.9	19	59.4
SUNFISHES					
green sunfish	I	1	*	1	3.1
bluegill	I	-	-	-	-
largemouth bass	I	-	-	-	-
TOTAL		18,573			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence are based on n=32 samples.

* Value is less than 0.05%

Table 11. Summary of Reach 5 (RM 131-154) 2003 San Juan River larval Colorado pikeminnow project fish collections. Samples collected between RM 141.5-131 representing 43.8% of Reach 5. Effort = 834.9 m^2

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	I	6,072	63.7	21	95.5
common carp	I	-	-	-	-
roundtail chub	N	-	-	-	-
fathead minnow	I	2,802	29.4	19	86.4
Colorado pikeminnow	N	-	-	-	-
speckled dace	N	144	1.5	11	50
undetermined Cyprinidae		-	-	-	-
SUCKERS					
flannelmouth sucker	N	5	0.1	4	18.2
bluehead sucker	N	68	0.7	7	31.8
razorback sucker	N	-	-	-	-
undetermined Catostomidae		-	-	-	-
BULLHEAD CATFISHES					
black bullhead	I	11	0.1	3	13.6
channel catfish	I	13	0.1	5	22.7
KILLIFISHES					
plains killifish	I	18	0.2	5	22.7
LIVEBEARERS					
western mosquitofish	I	392	4.1	16	72.7
SUNFISHES					
green sunfish	I	-	-	-	-
bluegill	I	-	-	-	-
largemouth bass	I	1	*	1	4.5
TOTAL		9,526			

[1] N = native; I = introduced

[2] Frequency and % frequency of occurrence are based on n=22 samples.

* Value is less than 0.05%

Colorado pikeminnow 2003

Larval colorado pikeminnow was not collected during the 2003 study period (Table 3) despite the large number of specimens taken (n=70,352). A single sub-adult (201 mm SL) was collected on 15 July at river mile 54.4. The specimen was collected in a shoreline pool on river right, just upstream of Mexican Hat, Utah. It is presumed that this indivdual was a stocked fish, and not a wild specimen.

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Appendix I. Detailed sampling and fish identification protocol.

1. Determination and access to sampling sites

a. Suitable habitats for larval fish, including areas of low velocity (isolated pools, backwaters, and secondary channels) were identified by field personnel while floating the river.
b. Access to the habitats was gained via 16' inflatable raft.
c. River Mile was determined to tenth of a mile using the 1988 aerial photos produced for the San Juan River Basin Recovery Implementation Program.
d. Geographic coordinates were determined at each site with a Garmin Navigation Geographic Positioning System (GPS) Instrument and were recorded in Universal Transverse Mercator (UTM) Zone 12 NAD27 CONUS. In instances where coordinates could not be obtained due to poor GPS satellite signal, coordinates were determined upon return to the lab using a Geographic Information System based on the recorded river mile.

2. Collection of larval fish samples via seine and associated data recorded

a. Small-mesh seines (1m x 1m x 0.8 mm) were drawn through the sampling site.
b. The number of seine hauls per site was recorded along with the length of each seine haul. This information was used to calculate effort (area sampled) using the equation:

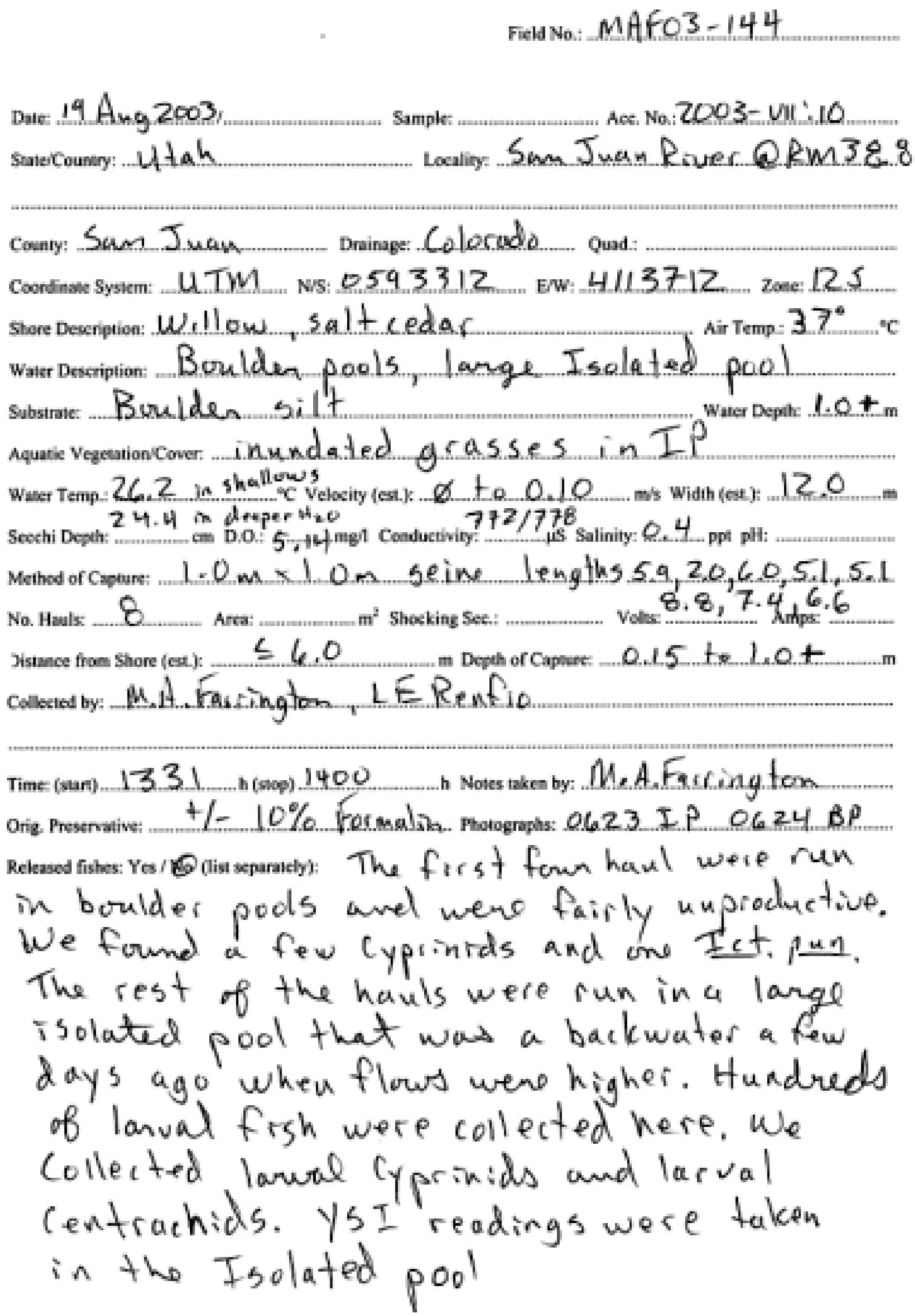
$$\Sigma \textit{haul lengths (m)} \bullet \textit{seine width (m)} = \textit{effort } (m^2)$$

c. Ecological data about each site were recorded, including meso-habitat type, length of habitat area, maximum depth, and substrate. A secchi disk was used to determine water clarity. Figure 11 illustrates how data were recorded at seining sites in the field.

3. Retention, identification, and permanent deposition of specimens

a. Retained specimens at each site were placed in WhirlPak bags containing a solution of 10% formalin and a tag inscribed with a unique alpha-numeric code that was also recorded on the field data sheet.
b. Samples were returned to the Division of Fishes, Museum of Southwestern Biology (MSB), University of New Mexico. The specimens were removed from the field bags, debris and silt was removed and they were transferred to glass museum jars with a solution of 5% buffered formalin. Specimens from each site were sorted and identified to species, then the species series were enumerated and measured for minimum and maximum size (mm SL).
c. Specimens were identified to species by MSB personnel trained in larval fish identification. Identifications were made using a polarized, underlit stereo microscope. Specimens whose species-specific identity was questionable were forwarded to Darrel E. Snyder (Larval Fish Laboratory, Colorado State University) for review.
d. All collections were transferred through a series of 35%, 50%, and ultimately 70% ethanol, catalogued, labeled, and placed on shelves in the in the collection archives of the MSB.

Appendix I. (continued) Detailed sampling and fish identificaion protocol.


Field No.: MAF03-144

Date: 19 Aug 2003 Sample: Acc. No.: 2003-VIII.10
State/Country: Utah Locality: San Juan River @ RM 38.8

County: San Juan Drainage: Colorado Quad.:
Coordinate System: UTM N/S: 0593312 E/W: 4113712 Zone: 12 S
Shore Description: Willow, salt cedar Air Temp.: 37° °C
Water Description: Boulder pools, large Isolated pool
Substrate: Boulder silt Water Depth: 1.0+ m
Aquatic Vegetation/Cover: inundated grasses in IP
Water Temp.: 26.2 in shallows, 24.4 in deeper H2O °C Velocity (est.): Ø to 0.10 m/s Width (est.): 12.0 m
Secchi Depth: cm D.O.: 5.14 mg/l Conductivity: 772/778 µS Salinity: 0.4 ppt pH:
Method of Capture: 1.0 m x 1.0 m seine lengths 5.9, 2.0, 6.0, 5.1, 5.1, 8.8, 7.4, 6.6
No. Hauls: 8 Area: m² Shocking Sec.: Volts: Amps:
Distance from Shore (est.): ≤ 6.0 m Depth of Capture: 0.15 to 1.0+ m
Collected by: M.A. Farrington, L.E. Renfro

Time: (start) 1331 h (stop) 1400 h Notes taken by: M.A. Farrington
Orig. Preservative: +/- 10% formalin Photographs: 0623 IP 0624 BP
Released fishes: Yes / No (list separately): The first four haul were run in boulder pools and were fairly unproductive. We found a few Cyprinids and one Ict. pun. The rest of the hauls were run in a large isolated pool that was a backwater a few days ago when flows were higher. Hundreds of larval fish were collected here. We collected larval Cyprinids and larval Centrachids. YSI readings were taken in the Isolated pool

Figure 10. Field sheet used to record data at larval seine haul site during Colorado pikeminnow sampling in the San Juan River in 2003.

Appendix II. (continued) Water quality data for individual collection localities in the San Juan River 2003.

Field Number	Date	RM	Water Temp (°C)	Disolved Oxygen (mg/L)	Salinity (ppt)	Conductivity (microsiemens µs)
MAF03-038	09-Jul-03	141.3	24.9	4.77	0.4	823
MAF03-039	09-Jul-03	141	28.6	5.94	0.3	567
MAF03-040	09-Jul-03	138.1	25.9	5.18	0.3	550
MAF03-041	10-Jul-03	136.8	18.3	2.94	0.3	497
MAF03-042	10-Jul-03	135.3	20.3	5.32	0.3	497
MAF03-043	10-Jul-03	134	23	5.66	0.3	524
MAF03-044	10-Jul-03	133.5	24.2	5.85	0.3	657
MAF03-045	10-Jul-03	132	22.2	4.55	0.3	528
MAF03-046	10-Jul-03	129.9	32.8	7.12	0.4	857
MAF03-047	10-Jul-03	128.7	28.5	5.8	0.3	584
MAF03-048	10-Jul-03	122.6	28.2	4.7	0.3	587
MAF03-049	11-Jul-03	119.7	22.3	5.89	0.3	514
MAF03-050	11-Jul-03	118.4	22.5	6.01	0.3	518
MAF03-051	11-Jul-03	117.2	26	4.69	0.3	621
MAF03-052	11-Jul-03	116.2	26.5	5.16	0.3	604
MAF03-053	11-Jul-03	113.2	36.4	4.88	0.3	679
MAF03-054	11-Jul-03	110	29.8	5.4	0.3	616
MAF03-055	11-Jul-03	109	29.1	5.24	0.3	577
MAF03-056	11-Jul-03	106.8	31.4	5.3	0.3	618
MAF03-057	12-Jul-03	105.5	22.1	5.02	0.3	516
MAF03-058	12-Jul-03	104.5	22.9	5.38	0.3	523
MAF03-059	12-Jul-03	101.6	26	5.85	0.3	558
MAF03-060	12-Jul-03	100.3	26.1	5.25	0.2	489
MAF03-061	12-Jul-03	96.5	29	5.1	0.3	599
MAF03-062	12-Jul-03	94.7	29.5	5.31	0.3	604
MAF03-063	12-Jul-03	91.7	29.8	5.2	0.3	609
MAF03-064	12-Jul-03	90.3	29.2	5.07	0.3	602
MAF03-065	13-Jul-03	87.4	22.4	4.98	0.3	522
MAF03-066	13-Jul-03	85.6	21.6	4.87	0.3	501
MAF03-067	13-Jul-03	83.9	25.2	5.38	0.3	568
MAF03-068	13-Jul-03	80	28.8	5.32	0.3	609
MAF03-069	13-Jul-03	78.6	28.6	5.36	0.3	606
MAF03-070	13-Jul-03	77.3	32.4	5.17	0.3	652
MAF03-071	13-Jul-03	75.2	31.7	4.8	0.3	663
MAF03-072	13-Jul-03	72.2	28.6	5.04	0.3	606
MAF03-073	14-Jul-03	70.5	25.4	5.09	0.3	554
MAF03-074	14-Jul-03	69.7	26.4	4.97	0.3	568
MAF03-075	14-Jul-03	66.3	27.3	4.87	0.3	575
MAF03-076	14-Jul-03	65.1	28.2	5.02	0.3	586
MAF03-077	14-Jul-03	61.8	29	5.13	0.3	591
MAF03-078	14-Jul-03	61.2	29.7	4.79	0.3	606
MAF03-079	15-Jul-03	58.1	24.3	4.56	0.3	545
MAF03-080	15-Jul-03	57	25.3	4.81	0.3	555
MAF03-081	15-Jul-03	54.5	26.3	4.65	0.3	564
MAF03-082	15-Jul-03	49.7	30.1	5.06	0.3	593

Appendix II. (continued) Water quality data for individual collection localities in the San Juan River 2003.

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Field Number	Date	RM	Water Temp (°C)	Disolved Oxygen (mg/L)	Salinity (ppt)	Conductivity (microsiemens µs)
MAF03-083	16-Jul-03	43.8	24.1	3.85	0.3	552
MAF03-084	16-Jul-03	40.3	26.8	4.68	0.3	533
MAF03-085	16-Jul-03	36.2	262	5.38	0.3	552
MAF03-086	16-Jul-03	33.1	27.9	5.48	0.3	570
MAF03-087	16-Jul-03	29.1	28.8	4.88	0.3	582
MAF03-088	16-Jul-03	28.6	35.7	4.58	0.3	680
MAF03-089	16-Jul-03	25.3	35.3	4.6	0.3	657
MAF03-090	17-Jul-03	21.3	25.8	5.3	0.3	549
MAF03-091	17-Jul-03	18.3	26.9	5.17	0.3	559
MAF03-092	17-Jul-03	15.9	28.9	5.32	0.3	602
MAF03-093	17-Jul-03	13	29	5.01	0.3	540
MAF03-094	17-Jul-03	11.6	30.8	4.79	0.3	531
MAF03-095	17-Jul-03	8.4	31.8	4.98	0.3	616
MAF03-096	17-Jul-03	5.9	32.6	3.83	0.3	694
MAF03-097	17-Jul-03	3.6	32.4	4.01	0.3	621
MAF03-098	04-Aug-03	140	27.2	0.18	0.7	1457
MAF03-099	04-Aug-03	139.1	27	4.41	1	1968
MAF03-100	04-Aug-03	135.3	24.9	4.94	0.3	696
MAF03-101	04-Aug-03	134.5	30.2	4.15	0.7	1503
MAF03-102	05-Aug-03	133.5	20.8	5.45	0.3	630
MAF03-103	05-Aug-03	131.3	21.4	5.2	0.3	630
MAF03-104	05-Aug-03	127.3	24.3	5.33	0.3	689
MAF03-105	05-Aug-03	126	24.7	0.31	0.4	878
MAF03-106	05-Aug-03	123	26.6	4.93	0.3	730
MAF03-107	05-Aug-03	121.1	26.6	4.97	0.3	723
MAF03-108	05-Aug-03	118.8	26.8	4.28	0.3	738
MAF03-109	06-Aug-03	116.2	22.6	0.52	0.4	863
MAF03-110	06-Aug-03	112.3	22.3	5.63	0.3	616
MAF03-111	06-Aug-03	109.5	25.4	4.97	0.3	665
MAF03-112	06-Aug-03	109	24.6	5.28	0.3	653
MAF03-113	06-Aug-03	106.6	26.1	4.99	0.3	664
MAF03-114	06-Aug-03	104.2	26.7	1.99	0.3	737
MAF03-115	06-Aug-03	102.6	23	2.9	0.3	630
MAF03-116	07-Aug-03	100.9	24.3	3.35	1.2	2256
MAF03-117	07-Aug-03	100.5	23.3	5.48	0.9	1815
MAF03-118	07-Aug-03	96.4	24.7	5.59	0.3	669
MAF03-119	07-Aug-03	92	26.2	5.04	0.3	698
MAF03-120	07-Aug-03	91.7	26.6	5.11	0.3	698
MAF03-121	07-Aug-03	89.1	26.1	5.16	0.3	694
MAF03-122	08-Aug-03	86	22.1	5.63	0.3	639
MAF03-123	08-Aug-03	84.5	23.1	5.4	0.3	662
MAF03-124	08-Aug-03	83.1	24.2	4.13	0.3	674
MAF03-125	08-Aug-03	80.6	26.8	5.22	0.3	709
MAF03-126	08-Aug-03	80.2	28.8	4.89	0.3	735
MAF03-127	08-Aug-03	77.3	28	5.03	0.3	724
MAF03-128	08-Aug-03	75.5	28.2	4.75	0.3	725

Appendix II. (continued) Water quality data for individual collection localities in the San Juan River 2003.

Field Number	Date	RM	Water Temp (°C)	Disolved Oxygen (mg/L)	Salinity (ppt)	Conductivity (microsiemens µs)
MAF03-129	08-Aug-03	73.2	29.1	4.42	0.4	759
MAF03-130	09-Aug-03	69.7	24.7	4.91	0.3	701
MAF03-131	09-Aug-03	68.4	25.1	5.47	0.3	705
MAF03-132	09-Aug-03	64.4	26.1	5.55	0.3	716
MAF03-133	09-Aug-03	63.2	29.6	4.65	0.3	768
MAF03-134	09-Aug-03	61.9	28.2	4.80	0.3	751
MAF03-135	09-Aug-03	59.3	28	4.96	0.3	743
MAF03-136	09-Aug-03	58	28.8	4.77	0.3	758
MAF03-137	10-Aug-03	56	24.5	5.33	0.4	736
MAF03-138	10-Aug-03	54.7	25.2	4.91	0.4	737
MAF03-139	18-Aug-03	51.2	25.1	5.48	0.3	712
MAF03-140	19-Aug-03	47.5	22.9	5.74	0.3	673
MAF03-141	19-Aug-03	45.3	23.7	5.34	0.3	685
MAF03-142	19-Aug-03	43.7	23.8	5.36	0.3	687
MAF03-143	19-Aug-03	40.6	24.6	5.68	0.3	700
MAF03-144	19-Aug-03	38.8	24.4	5.14	0.4	772
MAF03-145	19-Aug-03	34	26.1	5.43	0.3	709
MAF03-146	19-Aug-03	31.2	26.3	5.43	0.3	731
MAF03-147	19-Aug-03	30	25.9	5.21	0.3	729
MAF03-148	20-Aug-03	28.8	23.1	6.06	0.3	633
MAF03-149	20-Aug-03	25.2	23.4	5.84	0.3	641
MAF03-150	20-Aug-03	24.9	25	4.86	0.3	675
MAF03-151	20-Aug-03	22.3	24.8	5.37	0.3	662
MAF03-152	20-Aug-03	17.7	25.4	5.19	0.2	675
MAF03-153	20-Aug-03	15	26.6	5.01	0.3	690
MAF03-154	21-Aug-03	11.4	23.9	5.75	0.3	630
MAF03-155	21-Aug-03	9.6	23.7	5.55	0.3	629
MAF03-156	21-Aug-03	8	23.8	5.41	0.3	630
MAF03-157	21-Aug-03	4.8	25	5.51	0.3	648
MAF03-158	21-Aug-03	3.3	25	5.49	0.3	637
MAF03-159	05-Sep-03	141.4	20.7	6.6	0.6	1041
MAF03-160	05-Sep-03	140.9	22.7	5.65	0.4	693
MAF03-161	05-Sep-03	139.6	23	5.9	0.4	754
MAF03-162	05-Sep-03	137	23.3	5.56	0.4	727
MAF03-163	06-Sep-03	136.3	16.8	5.04	0.4	663
MAF03-164	06-Sep-03	133.7	21.2	6.33	0.4	726
MAF03-165	06-Sep-03	133.5	21.3	4.9	1.2	2172
MAF03-166	06-Sep-03	131.3	19.8	5.58	0.4	727
MAF03-167	06-Sep-03	129.3	20.1	6.02	0.4	718
MAF03-168	06-Sep-03	127.4	20.7	2.19	0.4	739
MAF03-169	06-Sep-03	125.3	21.3	0.46	0.5	852
MAF03-170	07-Sep-03	122.6	16.2	6.69	0.7	1120
MAF03-171	07-Sep-03	120.2	18.5	6.18	0.4	701
MAF03-172	07-Sep-03	118.4	19.9	6.16	0.4	720
MAF03-173	07-Sep-03	116.2	21.7	5.98	0.4	753
MAF03-174	07-Sep-03	111.9	23.1	5.95	0.4	745

Appendix II. (continued) Water quality data for individual collection localities in the San Juan River 2003.

Field Number	Date	RM	Water Temp (°C)	Disolved Oxygen (mg/L)	Salinity (ppt)	Conductivity (microsiemens µs)
MAF03-175	07-Sep-03	110	22.1	5.81	0.4	741
MAF03-176	08-Sep-03	109	17.7	4.81	0.4	658
MAF03-177	08-Sep-03	106.8	18.6	5.95	0.4	682
MAF03-178	08-Sep-03	103.3	19.4	6.13	0.4	692
MAF03-179	08-Sep-03	101.2	20.7	5.83	0.4	718
MAF03-180	08-Sep-03	100.5	21.4	5.96	0.6	1198
MAF03-181	08-Sep-03	94	21.7	5.91	0.4	790
MAF03-182	08-Sep-03	92.9	21.3	5.39	0.4	751
MAF03-183	08-Sep-03	92.2	21.8	5.17	0.5	857
MAF03-184	09-Sep-03	90.1	18.2	2.56	0.4	772
MAF03-185	09-Sep-03	86	18.1	5.79	0.5	800
MAF03-186	09-Sep-03	85.4	18.4	5.23	0.4	793
MAF03-187	09-Sep-03	84.1	20.3	4.96	0.4	809
MAF03-188	09-Sep-03	82.5	18.5	5.56	0.4	791
MAF03-189	09-Sep-03	81.9	18.3	4.98	0.5	795
MAF03-190	09-Sep-03	78.7	18.1	5.61	0.4	786
MAF03-191	09-Sep-03	77.1	18.2	5.6	0.4	754
MAF03-192	16-Sep-03	75.6	20.5	6.23	0.2	310
MAF03-193	16-Sep-03	75.1	21.5	6.25	0.3	624
MAF03-194	16-Sep-03	72.4	20.5	5.98	0.3	614
MAF03-195	16-Sep-03	65.3	20.2	6. 00	0.3	609
MAF03-196	17-Sep-03	62.4	17.1	6.53	0.3	579
MAF03-197	17-Sep-03	61.2	17.3	6.03	0.3	582
MAF03-198	17-Sep-03	56.7	17.9	6.64	0.3	591
MAF03-199	17-Sep-03	54.5	18.4	6.69	0.3	594
MAF03-200	17-Sep-03	52.4	18.9	6.52	0.3	6.6
MAF03-201	17-Sep-03	50.8	19.3	5.3	0.3	606
MAF03-202	17-Sep-03	46.3	19.9	6.55	0.3	611
MAF03-203	17-Sep-03	44.4	19.3	6.39	0.3	607
MAF03-204	17-Sep-03	41.6	20	5.9	0.4	693
MAF03-205	17-Sep-03	38.7	18.9	6.21	0.3	606
MAF03-206	18-Sep-03	37.1	15.3	7.01	0.3	564
MAF03-207	18-Sep-03	35.1	15.2	7.09	0.3	565
MAF03-208	18-Sep-03	28.1	15.5	6.9	0.3	569
MAF03-209	18-Sep-03	25.2	17.2	6.03	0.3	603
MAF03-210	18-Sep-03	22	16.8	7.22	0.3	560
MAF03-211	18-Sep-03	18.3	18.8	5.71	0.3	630
MAF03-212	18-Sep-03	15.5	18.2	6.18	0.3	613
MAF03-213	18-Sep-03	12.9	18.8	6.78	0.3	611
MAF03-214	18-Sep-03	11.3	21.1	6.36	0.4	778
MAF03-215	18-Sep-03	9.2	19.5	5.91	0.2	305
MAF03-216	19-Sep-03	7.8	14.8	6.47	0.3	563
MAF03-217	19-Sep-03	3.7	17.3	5.52	0.3	590